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IS IT TIME FOR A CLASS 5 LASER?

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Abstract

Since the development of laser safety standards, a classification system has evolved based on the laser's ability to cause tissue damage and/or ignite a fire. With only small nuances among them, there is a range of parameters that covers the categories of Class 1 to Class 3B. The highest category, Class 4, comprises everything else from simple hand held devices to industrial, military, and high energy or high power academic research systems. Some of these more powerful lasers can cause "immediate" danger to life and health. High average power and high-energy laser systems have the potential to seriously injure personnel beyond the simple skin burn or retinal lesion. This paper will discuss the overall laser safety classification system and consider the question of the usefulness of developing a standard for a Class 5 laser.

Introduction

Historically speaking, the current classification system has served well for most of the past 40 years that is has been in existence. To this day, its main concern has been to protect against eye injury and in fact, there still has not been a reported serious injury beyond retinal lesions related to the exposure of a laser beam. On the other hand, with rapid advancements in laser technology and the widespread use of high power and high-energy laser systems this situation is rapidly changing.

The futuristic projections for lasers of yesterday are fast becoming the reality of today. It is time to consider whether the current guidance are adequate for these increased hazards and whether we should differentiate a relatively low power hand-held laser from a laser light source capable of significant and rapid injury.

History of Laser Classification

From the advent of the laser in 1960 to around 1965, the only commonly available commercial lasers were the Ruby and the HeNe. In the United States, the first safety limits were developed for use by the military in 1962-63. Because only large organizations were using lasers during this period, there was no consensus standard available and several drafts for a national standard were circulating throughout the 1960s.

In 1965, the British Ministry of Aviation published a set of exposure limits based on continuous exposure with a varying retinal image size. In 1968, the American Conference of Government Industrial Hygienists (ACGIH) recommended exposure limits at the First International Laser Safety Conference (ILSC). Finally, in 1969 a request was made by the U.S. Department of Labor to develop a consensus standard. The American National Standards Institute (ANSI) initiated this effort [1].

In 1973, a laser product safety standard was published in the Federal Register which included laser hazard classifications. Initially lasers were broken down into two categories, "high-powered" which were a diffuse reflection hazard and "low-powered". The high powered eventually became Class 4. The ANSI committee was working on the new standard which consisted of several special interest groups; research labs, government agencies, and industrial manufacturers. These groups drove the dividing points for each of the classes. Eventually, the ANSI Z136.1 (1973) was released with the following classifications [2]:

- Class I Lasers were incapable of producing damage and were therefore "exempt" from controls.
- Class II Lasers were considered "low-power". They emitted in the visible portion of the spectrum (400nm-700nm).
- Class III Lasers were considered "medium power". They were a direct viewing hazard.
- Class IV Lasers were considered "high power". They were eye and skin hazards to direct and diffusely reflected beams.
- Class V Lasers were *enclosed* Class II, Class III, and Class IV lasers. They were not capable of producing damage.

Over the next 30 years, mostly minor modifications to the initial classification system were made. In 1976 the Class V, which was instituted for enclosed systems, was eliminated and became part of the category of Class I [3]. In 1980 the Roman numerals used for classification were changed to Arabic [4].

In 1986 the standard was further graded to include new subcategories to the 1-4 classification [5]. The additions were:

- Class 2a – This was instituted to include lasers or laser systems in the visible portion of the spectrum who's use is not intended to be viewed, provided that its accessible radiation does not exceed the Class 1 Accessible Emission Limit (AEL) for an exposure duration less than or equal to 103 seconds. This classification was made primarily for the ever-increasing use of bar code readers in the grocery and retail industries.
- Class 3a – This was instituted to include lasers or laser systems which have an accessible output power between 1 and 5 times the Class 1 AEL for wavelengths less than 0.4 μm and greater than 0.7 μm, or the Class 2 AELs for wavelengths between 0.4 μm and 0.7 μm. This classification was introduced primarily for laser pointers and construction lasers.
- Class 3b – This subcategory contained the remaining lasers in the Class 3 category.

No changes were made to classifications in the 1993 revision, but in the 2000 revision the category of the Class 2a laser was removed [6].

Finally, the 2007 revision contained the biggest changes to the classification system since the 1986 standard. These changes were made to bring uniformity with the European standard and included [7]:

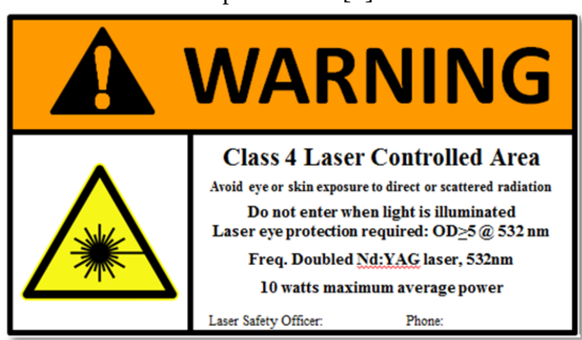
- Class 1M – This is considered to be incapable of producing hazardous exposure conditions during normal operation unless viewed with an optical instrument such as a loupe or a telescope.
- Class 2M – Emits in the visible spectrum (400-700nm) and protection is normally afforded by the aversion response, but is potentially hazardous if viewed with optical aids
- Class 3R – This is considered potentially hazardous under some direct and specular reflective viewing conditions if the eye is focused and stable, but the probability of injury is small. This essentially replaced the old Class 3a.
- Class 3B – The only change here is that the lower case "b" has been replaced with the upper case "B" as with the rest of the Arabic letters being used.

Again, the classification system concentrates on relatively low power systems with only one classification, Class 4, set aside for lasers that could cause other than eye damage.

Proposed Class 5 Laser

The question that we need to consider is if this is a rational approach in light of truly high average power, high peak power and high energy systems that exist today and whether a new class should be defined, a Class 5, to cover these potential hazards. The distinction between Class 4 and the proposed Class 5 should be so definitive, that simply creating a subcategory for Class 4 would not be appropriate. Exposure to a Class 5 laser beam, or its induced by-products (ionizing radiation), would cause "immediate risk of severe injury or potential for a fatality". A Class 4 laser would cover those laser systems where a direct or scattered beam could cause injury, and ignite a fire.

Posting requirements proposed in the new ANSI Z136.8 *for Safe Use of Lasers in Research, Development, or Testing, Section 4.2.7* calls for a Warning sign to be used for unattended laser operations (Class 3B and Class 4) at the exterior boundary of a non-interlocked laser use area that contains unattended open beams [8].



Laser Warning Sign use proposed by ANSI Z136.8

Section 4.6.3.4 calls for the use of a Warning sign (Class 3B and Class 4) posted outside of a Nominal Hazard Zone (NHZ), a temporary laser controlled area, or lifetime testing areas when open beam unattended operations in a non-interlocked area is present. It may also be used to warn staff of beams crossing walkways [8]. There is some confusion with the use of this new posting, primarily with the fact that it does not cover 3R lasers. The Class 3R would still require a "Danger" sign, which signifies a higher hazard.

To make easier application by the Laser Safety Officer (LSO) and for understanding by the user, the proposal for posting would be:

- Class 1 – No posting requirement

- Class 2 – Caution Sign
- Class 3R – Warning
- Class 3B – Warning
- Class 4 – Warning
- Class 5 – Danger

Because while many of the current laser systems that would fall under the Class 5 category are physically large, the trend of miniaturization continues and this may not be true in the future. The components might remain Class 4 while the operating areas that contained the application area might be posted as Class 5. Newer commercial built systems operating in this category would receive the Class 5 rating. Of course, guidance documents would recommend reducing the beam hazard, through engineered controls, to a Class 4 or lower emission level.

The current Class 4 from ANSI Z136.1 (2007) *for Safe Use of Lasers, Section 3.3.4* states, "Class 4 lasers and laser systems are those that emit radiation that exceed the Class 3B AEL [7]."

Example of Proposed Classifications

The purpose of this paper is strictly to pose the question and initiate discussion, therefore the separation point between a Class 4 and a Class 5 laser would be best left to the Z136 working group and/or subgroups.

The Proposal for the Class 4 might be: Class 4 lasers and laser systems are those which can emit accessible radiant power in excess of the Class 3B AEL during any emission duration within the maximum duration inherent in the laser or laser system, but which (a) cannot emit an average radiant power in excess of 10kW for T >0.25 seconds or (b) cannot produce radiant energy greater than 10J within an exposure time T <0.25 seconds.The Proposed Class 5 might be: Class 5 lasers and laser systems are those that emit radiation that exceeds the Class 4 AEL.

In terms of the Class 5 laser, one also needs to take into account the focused laser beam from short-pulsed lasers causing the generation of ionizing radiation. The proposed level might be that a Class 5 laser or laser system are those which may generate, in the area, a dose rate greater than 1,000 millirems (10 millisievert) in one hour 30 centimeters from the source or from any surface through which the ionizing radiation penetrates. The overall determination of this potential hazard and subsequent mitigation would require consultation with a Health Physicist.

Benefits of a New Classification

What would be the benefit of adding yet another category of classification? This seems like a good question on the surface considering the expansion of subcategories in the 2007 revision. One only need look at the readily available hand held devices that are Class 4 lasers. When you have a 500mW handheld laser that is in the same category as a 50kW military, industrial or research laser, there tends to be confusion and a lack of respect for the inherent danger of the latter. A Class 5 category may help change the culture of safety for these systems.

Proposed Class 5 Area Danger Sign

- The first benefit is, lasers that are potentially "lethal" or dangerous to life or health are provided a special category rather than mix them in with lasers that can cause a simple burn or retinal lesion. This creates a greater awareness and sense of deference for these more dangerous systems.

- The second benefit is that more stringent guidelines may be established for the use of these systems. Having explicitly defined guidelines provides a firm basis for LSOs when trying to implement adequate controls to address the level of hazard present. An example of this would be to prevent access to the area where these lasers are fired. Defined and descript guidelines would assist LSOs in restricting access to dangerous areas. These guidelines also would help remove the potential for a laser operator to ask for astronomical optical densities (OD) so that they can be in the room with the operating laser. It is likely that no level of OD would provide adequate protection given the hazard to the rest of the body for proposed Class 5 lasers.

- A modified Table 10 from ANSI Z136.1 for the proposed Class 5 might then require a full interlock control system built to "life safety" standards and would not allow access to a Class 5 laser operating area. Strict "sweep procedures" should be required to ensure that personnel are not left in the area when firing the laser. One additional guideline might be that Lock-Out-Tag-Out (LOTO) should be employed to control this class of laser rather than the laser power supply key.

- The third benefit of this classification is the true and correct usage of the danger sign. According to the ANSI Z535, the proper use of the Danger sign is to keep personnel out of a hazardous area. Having harmonized the ANSI Z136.1 and European laser standard (IEC 60825), implementing the proper usage of signage with the rest of the safety professions should follow.

- Finally, we should evolve the guidance on controls required for such lasers. As overall hazards increase, so should the competency and qualifications of the LSO. ANSI Z136.1 (2007) *Section 5.4* states, "The LSO training shall be commensurate to at least the highest class of laser under the jurisdiction of the LSO [8]." However, there is no specific guidance to the employer as to what this actually means. As a result, employers may already be accepting unintended levels of risk due to inadequately trained LSOs. This would be especially problematic with a laser of the Class 5 level and therefore specifically defined LSO qualification criteria may be warranted.

Lasers of Today and Tomorrow

Today, there are many lasers and laser facilities in operation that might qualify as a Class 5 laser. Fortunately, these systems are in the hands of large institutions and agencies where safety is paramount. Many of these are pioneers in developing the engineered and administrative controls used to operate the facilities safely and were instrumental in the development of the ANSI Z136.8 *for the Safe Use of Lasers in Research, Development, or Testing*. This is much like what was being done with airborne based laser platforms before the ANSI Z136.6 *for the Safe Use of Lasers Outdoors* was developed. The guidance of the Z136.6 is invaluable as more and more lasers are being operated in navigable airspace.

Several systems have been developed and tested throughout the years, both in the laboratory and deployed in the field. These solid state, free electron, and chemical lasers range from tens and hundreds of kilowatts up to megawatt class systems. Still, these types of lasers are generally under the control of institutions and agencies whose reputation and funding are dependent on operating safely. It is only a matter of time until they (lasers) find their way into general commercial use. There should be guidelines and controls in place when this does occur.

Foro Energy Portable 20kW Fiber Laser Drilling Rig

Current research into high power fiber lasers is very promising. While most work seems to be in directed energy military applications, just recently an order was placed for a 100kW fiber laser from IPG for deep-penetration welding in Japan. A Russian company has expressed interest in this laser to drill deep into the earth for gas and oil. This would be the highest power industrial laser ever built [9].

For the most part, the use of these higher power lasers have been in a controlled environment, but are beginning to spill over into the commercial world. Are we ready?

Summary

A tipping point with the use of high energy and high average power lasers is near. We are again at a place, as in the 1960s, where these types of lasers are in the hands of very large organizations. But, with the rapid progression in technology combined with lower cost, it is only a matter of time before commercially available and user built highly powerful and highly energetic lasers will be commonplace.

With the proposed usage of the "Warning" sign for Class 3B, and Class 4 lasers in the newly issued ANSI Z136.8, it is only natural to create a Class 5 laser for what the "Danger" sign was truly intended, imminent danger to life and health. This would both simplify the use of correct signage and bring real respect for these very high energy/power lasers.

The rapid advancements in laser technology are driving laser outputs higher and higher both in R&D and commercially. If we believe that our classification system requires sub-categories for fiber optics and laser pointers, we should surely ask the question, "Is it time for a Class 5 Laser?"

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Meet the Author

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